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This Issue

THE effective medical and industrial hygiene control program of the American Brake Shoe Company as outlined by L. E. Hamlin, M. D., and H. J. Weber serves as an excellent example of what can be achieved through a well conceived plan and the able execution of it . . . WHERE industrial hygiene is being instigated in South American countries through a cooperative arrangement, it is indeed fortunate that as well-qualified an engineer as Bernard D. Tebbens has been delegated to conduct this work. Results of his evaluation and control of dust exposures in the mines of Bolivia are discussed in his current paper . . . CO-OPERATION among the several groups interested in occupational disease control and improvement in working conditions for the preservation of health and well-being of working people is the keynote of the Presidential address presented at the Eighth Annual Meeting by Frank A. Patty, President of the American Industrial Hygiene Association over the past year . . . INCREASING application of automatic instruments in the field of industrial hygiene called for a review of this subjeect by Warren A. Cook in a paper included elsewhere in this issue.

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A Medical and Industrial Hygiene Control Program In Widely Scattered Plants

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and
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MEDICAL and Industrial Hygiene programs today have reached a stage of high efficiency in many large industries. In this paper we do not propose to discuss a stereotyped program but rather to touch on some of the high lights in our own experience over the past six years.

The American Brake Shoe Company originated a complete Medical and Hygiene Program in 1941 to service its 60 plants in 23 states and Canada. The number of employees in these plants varies from 60 in some to 1,000 in the largest—with an average of 250 to 300. There are 10 separate divisions, each of which is engaged in the manufacture of a different product. Six of the divisions, which include some 44 plants, conduct foundry operations producing grey iron, nickel and chrome alloys, manganese steel and brass castings. The other plants manufacture such products as upset and drop forgings, railway switches, frogs and crossings, special alloys, automobile brake linings, paint sprayers and compressors.

The Medical Department had its inception in 1941 through the efforts of the late Donald E. Cummings, then Professor of Industrial Hygiene at the University of Colorado. From a modest start with a staff consisting of a Medical Director, Industrial Hygiene Engineer and X-Ray Technician the department has grown to its present complement of ten and the company has recently approved a complete new building to take care of our expanding needs.

All health hygiene activities originate from the department in Chicago. These consist of pre-placement and periodic health examinations which include chest x-rays, blood tests and urinalyses. Examination forms, x-rays, etc., from all plants are checked and filed here as well as results of industrial hygiene surveys. Periodic plant health surveys are directed by the department and we have our own field x-ray equipment. Recently we have added a new mobile photoroentgen x-ray unit similar to that used by the public health and tuberculosis associations. We also have a comprehensive industrial hygiene program with a well-equipped laboratory for carrying out field surveys which are correlated with medical findings.

In addition we have an industrial nursing service which began with one full-time

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nurse in 1942 and now employs 25. In a few locations a single nurse takes care of two plants while in one area a very satisfactory arrangement allows a nurse to service two plants in other industries in close proximity.

The type of program matters little as long as it is effective and demonstrates the points of attack. Adequate records are essential but there is danger of going overboard on details in our enthusiasm to do a complete job. At one of our locations recently a personnel manager devised a very detailed form for prospective employees which contained a great many questions concerning background, previous experience and personal attributes. One question asked was "What hobbies do you have?" An applicant for work answered—"Chawin' tobacco." Perhaps he was serious and possibly the question was in order but the reply illustrates the point that if cooperation is desired in obtaining authentic information some thought must be given to the matter of intelligent questions. Not long ago a pilot told me of a similar form which all employees of his airline were required to complete. Many of the questions were so absurd that the routine reply to most of them consisted of a single word "Wheaties!" So let us keep the records straight. We have revised ours at least four times in the past six years in favor of simplicity without sacrificing necessary details.

Management Support

ONE of the first essentials in the success of any health hygiene program is cooperation and support from top management. Plant supervisors must be made to understand that the recommendations of the Medical Department have to be given serious consideration. Most progressive superintendents "catch on" quickly but always there are some who refuse to see the light. They resent fancied interference or what they feel is being told how to run their plants. The approach should be one of "selling" industrial hygiene and medical care rather than anything savoring of a dictatorial effort, otherwise one need not expect permanent results. A superintendent who carries out industrial hygiene recommendations because he **has** to cannot be expected to cooperate and he can find numerous apparently valid excuses for procrastination. Occasionally such an attitude can only be changed by pressure from top management but a threat to shut down a plant until corrective measures have been carried out, while it may be effective, is not productive of future industrial hygiene happiness.

Perhaps the biggest single factor in successful operation of an industrial hygiene plan is the need for thoroughly convincing the plant operating head of the obvious advantages of good hygiene and demonstrating how these can effectively result in better production, satisfied workers, less absenteeism, fewer occupational disease claims and lowered production costs. The superintendent is a key man who can make or break your program. Once **he** is convinced, the major part of your difficulties are over.

Sometimes the man from whom you least expect cooperation turns out to be your most ardent disciple. A pat on the back in the way of bringing his good showing to the attention of top management not only pleases his ego—a very human reaction—but makes him more determined than ever to surpass his already excellent record. Such an individual permits no slovenliness in his shop, tolerates no shortcutting or bypassing of established hygienic practices and insures appreciable results, which incidentally reflect credit on the Medical and Hygiene Department.

Many Aspects to Industrial Physician's Part in Program

THE part played by the doctor in industrial health and hygiene is an important one. Aside from his responsibility in directing the program he should never be unmindful of the necessity for cooperation with management and plant personnel. He must be familiar with the various plant operations and should display an intelligent interest in local procedures and

methods. Superintendents greatly appreciate a visit from the doctor and too many industrial physicians fail to realize the necessity of periodic tours of the plants they service. How can they evaluate a man's ability to perform a specific job unless they know exactly what it entails? Employees, too, notice the doctor's visits. This interest in them and their work inspires confidence and discourages fraudulent claims. It also increases management's respect for its medical service. In this way the doctor not only adds to his practical knowledge of industrial operations but finds a new interest which can become most fascinating. The importance of this familiarity with industry cannot be overestimated in the proper evaluation of occupational disease and industrial hazards.

A most important aspect of the doctor's work in industry is frequently the one which is most often neglected. I refer to the psychological side of industrial medicine. One of my most important duties is to give advice on problem cases, both to personnel directors and to the employee himself. The busy physician either cannot or does not take time to talk to an injured employee to tell him about his condition and explain why it is taking longer than anticipated for him to get well. He treats the ailment repeatedly and asks the man to come back again and again for dressings. Soon the employee becomes discouraged and wants to see another doctor. His dissatisfaction is reflected in the plant management which is greatly concerned about the health of its employees and very jealous of its safety and lost time record.

I have been impressed with the results of a half hour's or an hour's talk, if necessary, with numerous workers in our plants who have been dissatisfied with such treatment. I have seen them return to their jobs with a different outlook on life and renewed confidence in the doctor all because of a sympathetic hearing and explanation of their difficulties. Some of our operative heads feel that this is one of the best services our Medical Department renders. The industrial physician can and should include these practices as part of his medical service. His reward will be satisfied plant workers, the high regard of management and an inner feeling of compensation which cannot be evaluated in dollars and cents. If he does these things and makes an honest effort to keep abreast of the latest developments in industrial medicine he will not make himself ridiculous by doing such things as diagnosing a case of lead intoxication on a single stipple cell count or calling a man totally disabled from a mild, uncomplicated degree of occupational fibrosis simply because he has worked in a plant where there is some degree of dust in the atmosphere.

Fig. 1.
Industrial hygiene laboratory

Employee Participation

WE IN American Brake Shoe like to stress the human side of industry and often go far afield in this respect. Sometimes there is danger in going to extremes in such policies and results are neither appreciated or desirable. One of our plants recently invested a very considerable sum of money in a new shower and lunch room for its employees. It filled a long felt need and was modern in every respect. While the management was not looking for any great amount of credit for providing such adequate facilities, it did anticipate some favorable reaction on the part of the em-

ployees. Imagine its surprise when the only response was a grievance to the effect that instead of putting all that money into a building it should have been handed out to the men themselves.

Another plant, in order to improve conditions, installed a new Bradley fountain in its shower room. Shortly thereafter the superintendent informed me that it was a mistake and that they could not use it any more. On further inquiry it turned out that the employees insisted on using an ordinary bucket of water which they placed in the fountain and instead of soap they preferred to use small cores from the foundry with which to scrub their skins. Naturally, the accumulation of sand in the fountain soon stopped up the drain and put an end to its usefulness. One might say that this was management's fault but remember this was in the war years when the labor turnover was at its worst and strikes were often called for very trivial reasons.

Perhaps the psychological approach to new ideas is wrong. Workmen resent paternalistic attitudes and a "mother knows best" pose. Providing the new shower and locker room without taking into consideration the fact that perhaps the men would like to be consulted on what they might want in the way of such accommodations, possibly produced the unfavorable reaction.

The same objection should be considered when making recommendations for improving hygiene or exhausting machines. Too often plant managers, engineers, yes and industrial hygienists get their heads together and say "Now this is what has to be done on Joe Smith's job." Great care and thought are employed in designing the exhaust equipment and frequent conferences are held right on the job while the machine is in operation. Joe listens but no one asks **him** any questions or what **he** might think of the idea. He is paid to turn out his quota of parts and is not supposed to know what is best for him. Of course Joe has only operated this particular machine for a matter of twenty-five years or so and if **anyone** should know its peculiarities **he** should. Joe says nothing but he has his own ideas which not uncommonly are more practical than those of the expert. So what happens! Joe's machine is fitted with some new device. He is told to use it, but he does not like it. All these years he has done the job his way and it worked. Now they are going to embarass him with some new fangled contraption which he has resented from the start. He deliberately tries to circumvent the whole thing and usually manages to do a good job of it unless he is under pretty rigid supervision.

Now suppose the experts had come to Joe and said "Our hygiene survey shows that there is too much dust on this job and we want to clean it up for you. Here's what we have in mind, what do you think of it or how do you think it will work? Have **you** any ideas about it yourself, you have been operating this equipment all these years!" Joe's attitude is entirely different. He feels that he is of some importance and that consideration is being given to his years of experience of which he is naturally jealous. Instead of being a rank outsider he is now part of the team. He probably comes up with a notion that has real merit and possibly on a point the experts have overlooked. He sees it included and, from here on in, Joe is the most cooperative employee in the shop. He does his utmost to make it work because an idea o his is in it and he wants to demonstrate its worth. Moreover he is constantly on the lookout for more and more ways of improving things and management has made another convert to industrial health and hygiene. Perhaps the illustration is a bit overdrawn—I do not think so! It will not always apply but in general the psychology is so obviously right. Let us not forget to do a bit more of taking the man on the job into our confidence.

Periodic Industrial Hygiene Surveys

HEALTH hygiene programs in widely scattered small plants are sometimes difficult to institute. A well-planned pro-

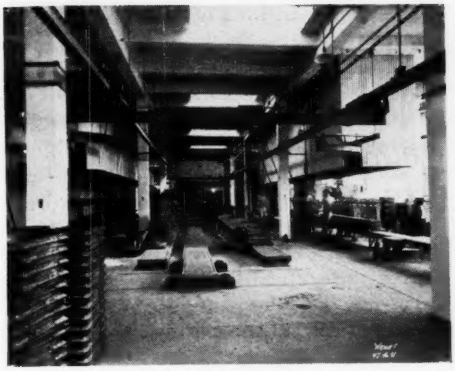

Fig. 2.
Interior of brass foundry. Note pouring being done under hood

cedure, directed from a central department, can be worked out but it must always be tailored to fit individual locations.

An industrial hygiene program for an organization comprised of 60 widely scattered plants presents problems which do not exist in an organization having one large plant. Furthermore, our company is composed of ten distinct divisions, each having different processes. Thus we are confronted with the following typical hazards:

Lead oxide	Iron oxides
Lead formate	Iron, steel, and brass welding
Silica	
Phosphorus	Chromium
Manganese	Acrolein
Tellurium	Various solvents
Asbestos	Carbon monoxide

To operate an industrial hygiene program under a variety of conditions—namely, dissimilarity of individual state health and labor codes, diversification of processes, kind and number of hazards—postulates first and foremost that the industrial hygiene department be given wide latitude in function, operating practically autonomously and responsible only to top management. While the department must remain an ancillary and advisory one, to be effective it must have the whole hearted backing of top management.

Our company operates throughout on the principle of bottom-up management. That is, each plant superintendent has full authority and full responosibility in operating his plant. This means that the industrial hygienist, while he can bring pressure to bear from above, finds his job to be one principally of selling the plant manager on control measures. This is as it should be and one finds that once you have convinced him, you have control of your hazards in absentia.

In our circumstances, and because of constantly changing plant processes, it becomes obviously important that all plants be thoroughly surveyed at least once a year and that those where the hazards are greater, at least twice a year. In fact, those plants in which we believe no hazard exists also should be surveyed annually because of changing conditions.

An interesting example of this occurred in one of our brake-lining plants. Lead formate, which is used in the manufacturing process, was received in the plant in 18 lb. packages—the exact weight required for a batch of lining. The only dust produced was during the actual emptying of the bags. This was done in an exhausted booth and hence no hazard was involved. During the war, the plant could get this material only in large drums so that it was necessary to weigh out each batch. The ventilation was not designed for this change of method, nor was the industrial hygiene department notified. On a routine survey the hazard was uncovered and corrected the next day. This condition could have gone on until real harm was done.

Besides locating unsuspected hazards, the regular routine survey has other advantages. To give an example: Asbestos is the principal ingredient in brake lining. A certain company carrying life insurance on the employees through their union classified all occupations in the plant as hazardous because of asbestos being used. The agent applying the rate did not investigate whether the asbestos hazard is controlled;

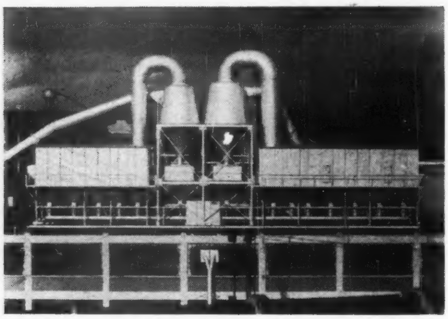

Fig. 3.
Cloth filter dust arresters with cyclone precleaner for asbestos dust at brake lining plant

took no cognizance of the fact that every individual machine has its own exhaust unit; disregarded the fact that the plant is a model of excellent housekeeping. He consulted his handbook under B for brake lining, found asbestos listed and made an unwarranted classification of hazard with a consequent increase in premium. The union approached management with their grievance. A photostatic copy of the report of the routine survey, showing dust counts of the order of one million particles per cubic foot and less, was sent to the insurance company and the rates were promptly revised. This had a three-fold effect. It showed the union we were there to help; it sold the industrial hygiene program to the management of the plant; and it impressed us with the importance of having quantitative records of hygienic conditions as derived from the routine survey.

We also encounter humorous things in our surveys. We have a plant in the south that makes only brake shoes—a grey iron casting. Our surveys indicated no hazard. However, during the war, we had a colored woman working in the core room. Whatever her motive, innocence, spite, or patriotism, she wrote to the President of the United States and informed him that the American Brake Shoe Company was making poison gases. Imagine the superintendent's surprise when he was shortly after confronted by a Colonel from the Chemical Warfare Service. Actually we did have some acrolein fume as a result of the decompositio nof core oil but it was below the allowable limit; and oddly enough, acrolein is a war gas! However, we do not make it; it just occurs and we are glad to get rid of it as soon as possible.

It cannot be stressed too much that

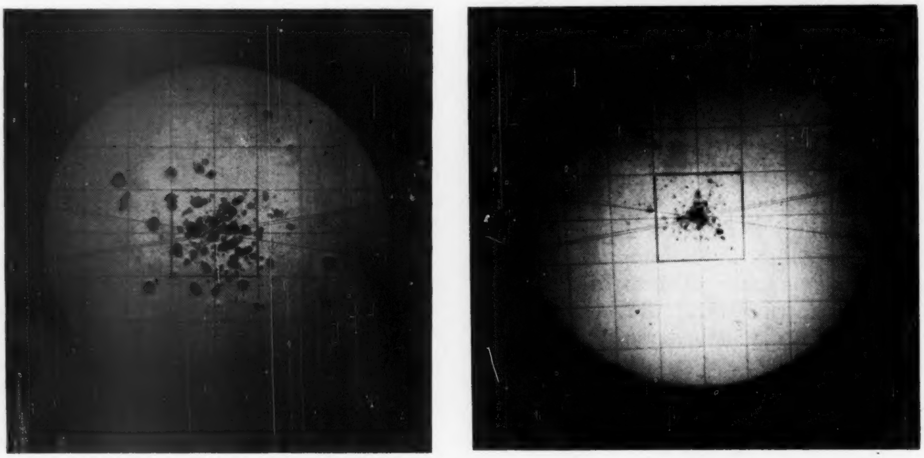

Fig. 4.
Konimeter samples of foundry dust
(a) Dust collected near shakeout. Note large size particles
(b) Dust from grinding operation in cleaning room. Note large number of very fine particles

plants must be surveyed at least annually. In this way we have found in so-thought safe plants: a potential beryllium hazard; a lead hazard in a plant melding "pure" copper ingot; explosive hazards in machine shops. We have even found lead in air in some of our offices in the brass foundries, although in safe concentrations.

Since we operate in 23 states and Canada, one can see the need for cooperation with other health and hygiene agencies. However, if they wish to survey our plants, we prefer to be present. This decision was arrived at after several experiences.

In one of our plants, these hygienists made quite an ado about a manual shakeout. To the eye, it would appear that the condition is extremely hazardous. Our repeated analyses proved that the contaminants were principally smoke, steam, and dust particles too large to be inhaled. However, these same men failed to take cognizance of a really hazardous operation because it did not appear to be dirty. Here we were concerned with high concentrations of fine pure silica. Their report to management was misleading, making it difficult for the company hygienist to rectify faulty reporting.

Again, we have a bearing plant in the northwest which formerly was hazardous. Air concentrations of lead were as high as 30 milligrams per 10 cubic meters and we found some as high as 300 milligrams per 10 cubic meters. We had about 14 cases of lead poisoning a month. By good exhaust and excellent housekeeping we have reduced lead in air to safe concentrations and we have not had a case of lead poisoning here in three years. We are proud of the plant and its accomplishments.

Co-ordination with Other Industrial Hygiene Agencies

RECENTLY an outside agency surveyed this same plant and wrote a report that we felt was unfair. Their report, of course, was based on air samples. Whether these were collected in a representative manner or whether their analyses were correct, we do not know. We do know that our urinalyses, our air samples, and especially our lack of cases of lead poisoning show good hygienic conditions.

In another plant, one inspector took samples of foundry sand to analyze for lead content and then proceeded to take a two-minute impinger sample of a cyclic operation, timing it with a wrist watch. We failed to see what information could be gained by either procedure and awaited interpretation of results with apprehension. If the field technique was such, what of the analysis and interpretation of results?

When one realizes that in some areas the recommendations of these inspectors have the force of law, it can readily be seen why we like to be present for plant inspections.

This is not to be construed as a condemnation of other industrial hygiene agencies. We have had some good surveys done by them which checked very well with our own. Our recommendations to management have greater weight when supplemented by a correct and representative survey by these departments; but we feel that we know our own plants better than outsiders because of the many investigations we have made in them, just as the family physician knows the idiosyncrasies of his own patients better than the casual specialist.

In many instances our maximal allowable concentrations are set lower than those of the organizations in question. Furthermore, we do x-ray diffraction and particle size separation in addition to the gross dust counts. One should not, therefore, be condemned on a single dust count alone, or be told a lead hazard exists because there is lead dust in the molding sand.

Analysis of Urine for Lead in Evaluation of Exposure

BECAUSE lead is our principal hazard those plants where it is processed are surveyed twice a year. But our best control is urinalyses. With plants widely scattered, the 24-hour sample or the eight hour sample becomes impractical. We therefore resort to the use of spot samples. However, there is a wide diurnal fluctuation in urinary excretion rates so that a single spot sample has little meaning; one

must consider the central tendency of many samples in order to use the spot sample as a reference norm of exposure. This means mass urinalyses (4000 - 5000 a year), and to do this with one analyst, one must resort to rapid methods such as polarographic determinations. In this way, urinary excretion rates will correlate with lead-in-air concentrations and the spot sample then becomes an effective control tool ideally adapted to decentralized industry. (Table 1.) Urinalyses are supplemented by blood analyses when indicated.

Table 1
CORRELATION OF URINARY LEAD EXCRETION RATES WITH LEAD IN AIR

*Lead in Air Mg/10 Cu. M.	+Urinary Lead Micrograms/Liter
16.8	640
16.2	440
15.0	310
13.7	450
13.0	310
10.9	370
8.3	280
6.8	280
6.7	230
4.3	202
0.4	75

*Average of 5 samples at each station.
+Average of all employees exposed.

Here are a few examples of the usefulness of spot samples used as explained:

In the machine shop of one of our plants, the air was as clear as one would expect in an office. No hazard was known to exist there. During routine urinalyses, it was noticed that a certain lathe operator was excreting hazardous amounts of lead. An air sample was then collected at this work station and it was also high in lead. Investigation revealed that a new type of centrifugally cast bushing was being machined and the lathe was making the initial rough cut which gave off fine particles of brass dust. The lathe was hooded and both lead in air and urinary lead fell to safe values.

Again in another plant, one of our men was working in a reclaim room. The metal reclamation is a wet process and our air samples showed it to be safe. During routine urinalysis, we noticed that this em-

Fig. 5.
Determination of lead in urine using a recording polarograph

ployee's lead excretion rate was dangerously high. Investigation of the case revealed that he had begun a practice of drying out his reclaim trough with wheelabrator dust. The scattering of this material created a hazardous exposure.

These and many other hazards were discovered by the spot sample soon enough to prevent deleterious effects.

Approval of Ventilation, New Processes and Materials

OUR industrial hygiene program has also the following features:

1. All ventilation design, plant construction, change n process, must be approved by the medical department before execution.

2. New materials must be submitted for an opinion on toxicity before they are used on a large scale.

This latter rule had its origin in an odd way. In one of our plants where machining is the principal operation, we suddenly had an unusually large number of cases of dermatitis. The cutting oils were suspected. Samples of the oil before and after normal use were sent to us but we were unable to find any fault with them. Furthermore, these types of oils had been used for years before without any trouble. We then requested samples of the hand soap being used. Our analysis showed it to be sand,

trisodium phosphate, and some soap. We changed to an approved type and the trouble cleared up.

In summation, it may be said that our industrial hygiene program has the following salient features:

1. Backing by top management.
2. The department is responsible only to top management.
3. Full latitude of operation is permitted.
4. Financial assistance in research problems is given.
5. Attendance at scientific meetings and membership in scientific societies at the company's expense is encouraged.
6. Authority to acquire necessary equipment is readily granted upon justification.
7. While the program can be forced from the top down, it is sold from the bottom up.
8. All divisions annually budget sums of money for improvements in plant hygiene, and the medical department has the principal voice in deciding what those improvements will be.

11W-CONS. PLANT: NBD - St. Louis, Mo.

EMPLOYEE	DEPT. / PREVIOUS LEAD EXPOSURE?	RACE / DATE OF BIRTH / DATE HIRED	CLOCK NO. / STUDY NO.
Doe, John	DEPT. Molding PREVIOUS LEAD EXPOSURE? No	RACE White DATE OF BIRTH 5-2-16 DATE HIRED 1-28-46	CLOCK NO. 247 STUDY NO. 1N-6749

ILLNESS RECORD		ANALYSIS OF SPOT URINE SAMPLES					
DATE		DATE	G/L	G/H	DATE	G/L	G/H
4-19-47	To Dr.	2-15-46	190/185	No Time			
4-23-47	Blood Anal. Rec'd. (106.2)	5-1-47	94/98	6			
		5-8-47	98/82	5			
		5-21-47	225/244	16			
		6-2-47	252/179	23			
		6-17-47	225/244	17			
		7-16-47	102/115	8			
		7-30-47	133/139	7			
		8-12-47	130/147	8			
		9-18-47	115/116	7			
		10-2-47	230/163	20			

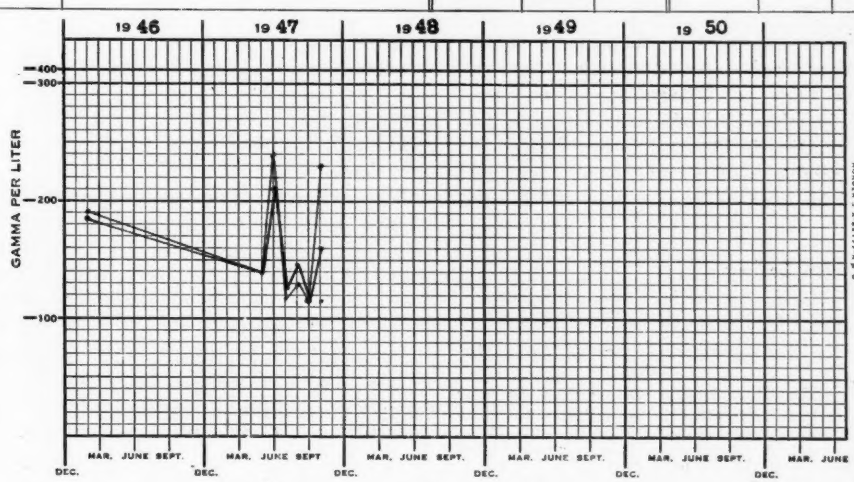

Fig. 6.

Lead-in-urine card. Above is obverse side. Under the heading, G/L, the figures at the left are gammas per liter corrected for specific gravity. The graph showing the trend of urinary lead excretion is on the reverse side of the card

Dust Concentrations in Bolivia's Mines

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La Paz, Bolivia

DURING the past year the Division of Industrial Hygiene and Safety of the Labor Section of the Servicio Cooperativo Interamericano de Salud Publica has been engaged among other duties in making studies of dust concentrations in the mines of Bolivia. This type of study is of utmost importance in Bolivia because of the demonstrated necessity of controlling silicosis. No such studies have been carried on previously, but since part of the program is the training of government personnel, it is anticipated that dust studies and other aspects of industrial hygiene will be carried on continuously after the dissolution of this section of the Servicio Cooperativo Interamericano de Salud Publica.

The purpose of this paper is to present some of the clean-cut conclusions which have emerged from the dust counts made in nine mines in various parts of the Republic. These counts show the dust conditions resulting not only from certain types of mining operations but from some relatively wet and relatively dry mining areas. The summarization of the results definitely points out the places where special care is needed in dust control. Such studies have been made for many years in the United States. Especially, these studies in Bolivia indicate that the same methods of dust control may and should be used as are used in the United States.

Dust From Drilling

IN TABLE 1 are shown the dust concentrations in a number of mines resulting from drilling operations. In all cases the dust counts are reported in millions of particles per cubic foot of air, which is a standard measurement. The dust counts were made in the breathing area of the workers immediately involved.

The table shows not only individual dust concentrations but also the average concentrations encountered from using pneumatic drills with and without water and from using hand drills. Although hand drilling is not dusty, it is obvious that machine drilling is both more efficient and more dangerous from the standpoint of inhalation and dust. Although dry pneumatic drilling is an outmoded technic, it was observed in many locations. In some cases it was accidental, in some cases it appeared to be the result of carelessness on the part of individual miners, and in cases it was standard mine practice.

On the average, dry drilling caused dust exposures more than 20 times as great as did wet drilling. Dust concentrations of the average magnitude found in dry drilling, namely 539 million particles per cubic foot of air, will undoubtedly cause silicosis even when the dust contans relatively low content of free silica. Therefore, every effort should be made by management, by miners, and by all others concerned to eliminate completely the machine-drilling practices.

The average result found from the use of wet drills is approximately that found in the United States from the same operation when there is relatively little ventilation. For example, in a group of hematite mines in Alabama, Tebbens and Tabershaw found average dust concentrations of 22 millions particles per cubic foot of air from wet drilling operations. Thus the effectiveness of this dust control method is as valid in Bolivia as in other parts of the world. There is needed a safe mining

The Inter-American Cooperative Public Health Service (Servicio Cooperativo Interamericano de Salud Publica) was created by the Institute of Inter-American Affairs representing the United States Government and the Ministry of Health and Labor of the Government of Bolivia for carrying out a health and sanitation program in Bolivia.

TABLE 1.
DUST CONCENTRATION FROM DRILLING
(Millions of particles per cubic foot of air)

Mine	Wet Machine	Dry Machine	Hand
A	38		
	36		10
	27		
	62		
	32		
B		466	
		79	
		59	
		89	
C	12	1667	
	47	1695	
		1463	
D	15		
	12		
	13		
E			13
		462	12
F	14		
	15	38	
	13		
G			10
			10
			14
			7
H		619	
		83	
		635	
		54	
J			7
			5
			4
			7
			4
Av.	26 (13 samples)	539 (13 samples)	8.5 (12 samples)

operation from the standpoint of industrial diseases.

Two points should be mentioned concerning wet drilling; namely, that wet drilling is usually more efficient than dry, and that for most effective dust control, the amount of water-flow through the drill steel should be about 3 or 4 liters per minute. For best results, water should be furnished to the drills by means of pipe lines to the work places.

Dust from Mineral Transfer

IN THE studies of the transfer of minerals from buzones to cars and vice versa it was noted that little attention was given to the sprinkling of ore as a means of dust control. In some mines the ore was very wet from natural seepage of underground water. In Table 2 the results are summarized to show the difference in dust counts from mineral transfers in relatively wet and in relatively dry mines. It is apparent from this comparison that the wetness of the ore has a profound effect on

Table 2.
DUST CONCENTRATION FROM MINERAL TRANSFER
(Millions of particles per cubic foot of air)

Mine	Wet Area	Dry Area
A		276
		29
		271
		38
B	40	
C		114
		374
		122
		64
		141
		105
D	3	
E	7	
F	7	
H		4
		41
J	14	
Average	14 (5 samples)	130 (12 samples)

the amount of dust produced by the transference of ore into and out of underground ore pockets.

In Bolivia the mines which are usually sufficiently wet to prevent excessive dustiness in mineral transfer are those situated in the Cordillera Real. In other locations, during a large portion of the year at least, the mines are apt to be relatively dry. In such mines ore should be sprinkled sufficiently with water so that excessive amounts of dust will not be dispersed during its transfer.

Dust from Mucking

THIS same precaution should apply also to mucking operations, particularly when the shoveling is done by machines. Table 3 shows dust concentrations from hand and from machine mucking. It is obvious that mechanical shovels tend to create much more dust than hand shovels.

Table 3.
DUST CONCENTRATION FROM MUCKING
(Millions of particles per cubic foot of air)

Mine	By Hand	By Machine
A	35	
	9	
	3	
	3	
B		86
C		67
E	3	
	3	
F		4
H	49	
	14	
	7	
Average	14 (9 samples)	52 (3 samples)

Therefore with mechanical mucking it is especially necessary that water be sprinkled on the ore to reduce dust dispersion.

In general it may be said that the increase of use of mechanical equipment increases the likelihood of dust production. It is almost invariably necessary to take extra precautions for dust control when a mine is mechanized. Since the use of water is a relatively inexpensive means of dust control, it should be widely exploited.

Dust from Blasting

A FEW samples serve to indicate the dust conditions that exist after blasting. These are shown in Table 4 together with the length of time that elapsed between blasting and sampling. Both time to allow for settling of dust, and ventilation to remove dusty air from the work places are essential following blasting. It is the best practice to blast at the end of the shift and to allow at least a two-hour interval before persons re-enter the blasted area. Water may be used in a fine mist to help to settle dust in such locations. This latter practice has not been observed in Bolivia but has been used successfully in other mining countries.

Table 4.
DUST CONCENTRATION FROM BLASTING
(Millions of particles per cubic foot of air)

Mine	Concentration	Time after Blasting
C	74	20 min.
J	65	30 min.
G	79	45 min.
F	7	150 min.

Dust from Wet and Dry Areas

IN TABLE 5 there have been summarized the dust concentrations from all operations except drilling in mines located in dry and in damp areas in Bolivia. Again it is clearly indicated that on the average there is less dust produced in damp mines, which reiterates the advantage which may be gained by the use of water for dust control. However, it is pointed out that dust concentrations are excessive even in the damp mines and that further attention should be given to dust control throughout Bolivia.

Table 5.
DUST CONCENTRATION FROM ALL OPERATIONS EXCEPT DRILLING
(Millions of particles per cubic foot of air)

Mine	Damp Areas	Dry Areas
A		725 (13)
B	182 (4)*	
C		1171 (17)
D	16 (3)	
E	336 (4)	
F	25 (5)	
G	89 (2)	
H		153 (6)
J	79 (2)	
Average:	36 (20 samples)	57 (36 samples)

* Figures in parentheses show number of samples

General Dust Prevention

IN GENERAL, silicosis is the result of inhalation over a long period of finely divided particles of uncombined (or free) silica. Other dusts mixed with silica may affect somewhat the rapidity with which the disease is contracted. As a general guide to the limits in the amount of dust which may be considered safe when quantities of free silica are present, the allowable concentrations are suggested:

Dusts containing more than 70% silica	— 5 m.p.c.f.*
Dusts containing 40 to 70% silica	—10 "
Dusts containing 5 to 40% silica	—20 "
Dusts containing less than 5% silica	—50 "

These figures are based on studies made in the United States, and if the average dust concentrations are maintained lower than these figures it is felt that the incidence of silicosis will be reduced to a negligible quantity. It is again emphasized that the use of water for drilling, mucking, mineral transfer, and other operations is an economical means of dust control.

To keep dust concentration below the quantities suggested above, particularly in highly siliceous rock, it is usually also necessary to provide frequent air change by means of ventilation in the working places. The failure of natural ventilation adequately to reach stopes and development headings is the main fault of ventilation as observed in Bolivia. In almost all mines auxiliary forced ventilation by means of blowers and tubing should be used to provide fresh air in such locations. In general auxiliary blowers should be capable of

*millions of particles per cubic foot.

forcing at least 35 cubic meters of air per minute into active working places, and the tubing which carries such fresh air from main air courses should be at least 35 cm. diameter.

Acknowledgement

THE assistance of a number of Bolivian technicians in making the dust counts mentioned in this paper is acknowledged. These men, Manuel Caceres, Jose Ferreyra, Jaime Escobari, Carlos Oroza and Alejandro Revilla, have been and are being trained in the technics of industrial hygiene and safety and will constitute the future corps of engineers in this field who will carry on this work in the Bolivian government, and in private mines of the nation. The cooperation of the various mine managements is also acknowledged.

AIHA Presidential Address

FRANK A. PATTY

IT IS encouraging and inspiring that the several societies comprising this conference can choose a field of common interest where we can sit down together in a spirit of cooperation and good fellowship to discuss and learn more regarding our common problems—the prevention of occupational disease, the improvement of working conditions, and the preservation of the health and well-being of all working people.

The desire to feel one's own importance is said to be the deepest urge in human nature. Without taking issue with this statement I will grant that the urge is deep, but, the moment we let the desire for recognition or self importance obscure our desire to do our particular job well, we are headed for the rough and are likely to find our game somewhat below par. If, on the other hand, we consistently keep an eye on the ball without letting our attention be unduly distracted by thoughts of remuneration, political advantage, prestige, or even fear of disapproval of administrators, we are likely to make a showing when the scores are tallied.

Among the requisites for the completely successful advancement of hygiene and health of the bread-winning population are:

1. Competent persons in health-maintenance work.
2. Managerial interest and appreciation of the benefits to be derived from health and safety work.
3. Teamwork: Camaraderie and cooperative efforts among industrial hygiene, medical, nursing, and safety personnel.

This last requirement is all too often ignored or forgotten and, unless good fellowship and cooperation is practiced and developed, a feeling of personal self-sufficiency or professional superiority is likely to hinder progress. We advance by our association with our fellow men. Especially is that true when our associates have some characteristic, some quality, or some goal in common with us. Unless the cooperative effort to get the job of health maintenance done supercedes professional pride or jealousy, management is first confused, then alienated, and the success of any program is jeopardized. I believe that one of the valuable benefits that we all derive from one of these conferences is an appreciation of what is being done in allied fields and an opportunity of becoming personally acquainted with the outstanding workers in those fields.

For our part we, in the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION have as one of our objectives the bringing together of all persons active in the various phases of industrial hygiene. If, during the period I have been honored with the office of President of this society, I have contributed something to foster the mutual respect and feeling of good fellowship between physicians and the other professional men and women engaged in industrial health maintenance, I shall have been amply rewarded for any effort I have expended. I have been deeply appreciative of the opportunity.

Presented before the Industrial Health Conference, Eighth Annual Meeting, AMERICAN INDUSTRIAL HYGIENE ASSOCIATION, Buffalo, New York, April 30, 1947.

Review of Automatic Indicating and Recording Instruments for Determination of Industrial Atmospheric Contaminants

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NOT SO many years ago, determination of industrial atmospheric contaminants was a matter of chemical analysis, often laborious, of individual air samples. Although the industrial hygienist must continue to use such methods in many instances, he has available an increasing number of automatic indicating and recording instruments which permit much more complete data with greatly decreased expenditure of effort. In fact, the major part of the effort is in the devising of the instruments rather than in the using of them. However, judgment and experience are still necessary in obtaining data and in the interpretation of it.

Without assuming to present an exhaustive treatise on these instruments, a number of the principles on which they are based will be outlined with examples of the application of each to instruments which can either be constructed or purchased as commercial models.

Heat of Combustion—Measured by Thermopile

A DIRECT method of measuring the concentration of a combustible gas is to burn it catalytically and then measure the heat produced by means of a thermopile. The resulting electric current is indicated on a milliammeter calibrated directly in terms of the concentration of the gas or is recorded on a chart.

Probably the first truly recording industrial hygiene instrument was the carbon monoxide recorder which employed this method as developed at the U. S. Bureau of Mines[1] for installation in the Holland Tunnel. A modern unit of this equipment such as has been built by the Mine Safety Appliances Company for the major vehicular tunnels throughout the world is shown in Fig. 1. The initial instruments were designed with a full-scale range of 0 to 0.10% carbon monoxide in air and the recording potentiometers were equipped with contacts for operating a series of signal circuits to indicate the approach of dangerous concentrations of carbon monoxide in the tunnel air.

The first of these instruments used a relatively large air sample flow and acid train scrubbers. Later, semi-automatic models were developed, using alumina tower dryers which required manual reversing at 12-hour intervals; and now, fully automatic units require substantially no attention in continuous operation.

This same principle is employed in the widely used portable carbon monoxide indicator and the industrial type of carbon monoxide alarm. This latter instrument continuously indicates the concentration of

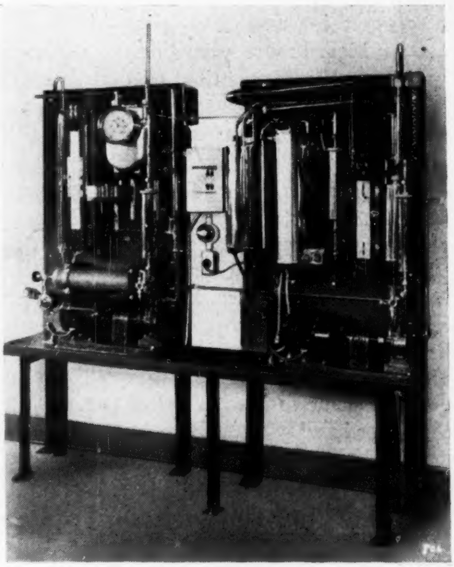


Fig. 1.
Carbon monoxide recorder

carbon monoxide and also rings an alarm when this gas reaches a predetermined setting of two to four parts per thousand; or it may be connected through a relay to ventilation equipment which is either placed in operation or shut off as atmospheric contamination requires.

Heat of Combustion—Measured by Electrical Resistance

A SECOND method of determining the concentration of a combustible gas is by measuring the heat of combustion through change of the electrical resistance of a heated wire filament in a Wheatstone bridge circuit. The changes in electrical current can be shown on a dial, usually

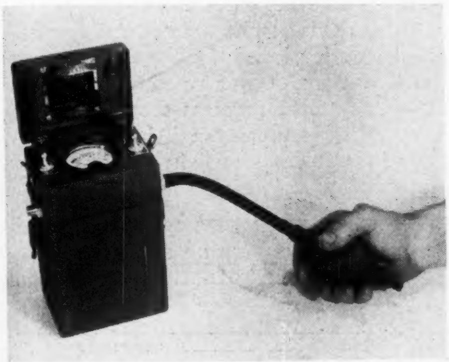


Fig. 2.
Flammable vapor indicator

calibrated in the ratio of the gas to the lower explosive limit (L. E. L.), can actuate an alarm, or make a continuous record on a chart.

Instruments of this type are widely used for determining the flash-fire and explosion hazards of flammable gases and vapors. They are also adaptable to indication of the toxicity of many combustible vapors where great sensitivity is not required.

One such indicator, Fig. 2, produced by the Davis Emergency Equipment Company, registers from zero to the lower explosive limit with the first graduation indicating two-hundredths of the lower explosive limit. Thus, where the L. E. L. of gasoline is 1.5%, the first graduation indicates 300 parts per million, a safe atmosphere as to health, irritation, or flammability. A more sensitive instrument is also available for use in determining lower concentrations where information on the more toxic flammable vapors is desired. The scale registers one tenth the concentrations of the standard instrument just described. For example, a concentration of 30 ppm of toluene would be indicated by a reading of one division on this instrument, well below the MAC of 200 ppm.

This same principle is used in the Davis Combustible gas alarm system, whereby samples may be continuously taken at one or more remote points. The percentage of the L. E. L. is indicated on a large dial on which is also mounted a recorder and, when a dangerous concentration is reached, an alarm sounds or control equipment can be actuated.

Equipment using this principle is produced by the Mine Safety Appliances Company. Recording apparatus has been calibrated so that the full-scale range may represent concentrations of 0 to 10%, 0 to 20%, or 0 to 100% of the L. E. L. as required.

To meet a demand for a portable recording instrument, the Mine Safety Appliances Company has mounted a recording potentiometer and analyzer with the necessary accessories on a rubber-tired truck as shown in Fig. 3. This can be wheeled from one

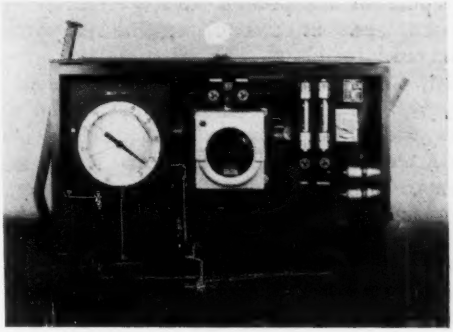


Fig. 3.
Mobile combustible vapor recorder

part of a plant to another and set up to show vapor concentrations as they occur throughout a shift, or even over several days, indicating all the peaks and valleys of concentrations as they occur. This obviously gives a more comprehensive picture of the exposures than is possible through a few spot samples.

Small portable indicators are also produced by the Mine Safety Appliances Company—one which includes a more sensitive scale with a range of 0 to 30% of the lower flammable limit and other called the "benzol indicator." This latter instrument is as sensitive as it is practical to construct a portable instrument of this type and is applicable to the determination of low concentrations of the more toxic flammable vapors such as benzol.

Ultra-violet Absorption Methods

VAPORS absorb radiant energy to varying degrees. The partial opacity also varies with different regions of the spectrum. By using ultraviolet light to which air is essentially transparent, the relatively high opacities of many vapors permit photometric determination of very small concentrations of them.

It must be known what compounds are present and which of these are opaque to ultraviolet and which are transparent. As shown in Tables 1 and 2, the method shows good sensitivity for such vapors as mercury, perchoroethylene, trichloroethylene, and pentachloroethane, but does not respond to vapors of compounds closely similar to these such as carbon tetrachloride and tetrachloroethane. The instrument originally known as the "R & H Tri-Per-Analyzer," so-called because it was developed especially for analyzing concentrations of tri-chloroethylene and perchloroethylene at vapor degreaser tanks, has been described in detail by Hanson.[2] This instrument is now commercially available through the Mine Safety Appliances Company and is known as the MSA photoelectric vapor and gas analyzer Fig. 4. For the present the instrument is recommended only for trichloroethylene and perchloroethylene since there has not been sufficient work done on its use with other gases and vapors.

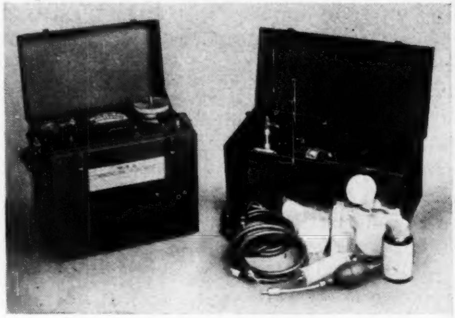


Fig. 4.
Photoelectric vapor and gas analyzer

An ultra-violet photometer and recorder has been developed for measurement of concentrations of war gases by Klotz and Dole. The equipment as shown in Fig. 5 is described in much detail in the original publication.[3] Its sensitivity for a number of war gases and other vapors is given in

TABLE 1.
MAXIMUM SENSITIVITY OF R. & H. TRI-PER-ANALYZER TO VARIOUS VAPORS

		Sensitivity P. P. M. Scale Division
a.	Mercury (approx.)	.0001
b.	Tetraethyl lead	.13
c.	Xylene	.2
d.	Monochlorobenzene	.3
e.	Aniline	.3
f.	Perchloroethylene	0.5
g.	Toluene	1.0
h.	Chloroprene	1.0
i.	Benzene	1.2
j.	Vinyl acetylene	2.0
k.	Phosgene	5
l.	Acetone	5
m.	Ethylbenzene	5
n.	Pentachloroethane	7
o.	Hydrogen sulphide	8
p.	Trichloroethylene	10
q.	Carbon disulfide	12
r.	Normal heptane	25
s.	Gasoline ("Blue Sunoco")	50

TABLE 2.
THE R. & H. TRI-PER-ANALYZER DOES NOT RESPOND TO THE FOLLOWING:

a.	Methylene Chloride	i.	Methyl alcohol
b.	Carbon tetrachloride	j.	Ethyl alcohol
c.	Dichloro-difluoro methane	k.	Amyl alcohol
d.	Ethylene dichloride	l.	Ethyl acetate
e.	Tetrachloroethane	m.	Ethyl Cellosolve
f.	Chloroform	n.	Methyl Cellosolve
g.	Methyl chloride	o.	"Dowtherm A"
h.	Vinyl chloride	p.	Water vapor

Table 3. Among the gases which do not absorb ultra-violet radiation (2537 wave length) are arsine, hydrogen cyanide, and cyanogen chloride. This instrument is battery operated, but the batteries will last three or four months even if it is used daily. The value of the instrument is increased by recording essentially instantaneous readings, the lag in the electrical circuits being completely negligible.

TABLE 3.

Gas	Sensitivity P. P. M. (by volume)
Chloropicrin	1
Phosgene	1
Mustard gas	3
Chlorine	3
Nickel carbonyl	0.5
Iodine	0.5
Toluene	0.2
Chloroacetophenone	0.03
Mercury	0.0001

Fig. 5.
Ultraviolet photometric vapor and gas recorder

Infra-Red Absorption Methods

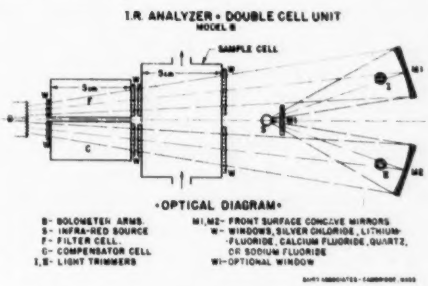
THE infra-red spectrometer is applicable to many specific gas-analysis problems. The most important property of infra-red absorption is its selectivity. Some compounds cannot be differentiated because they have a common absorption bond. Infra-red instruments may utilize any of three principles:

1. Selective source—a hot gas emits the same type of radiation it absorbs. Consequently, a hot jet of carbon dioxide would be used in analyzing a gas for its carbon dioxide content.

2. Selective detector—the only radiation which can heat a gas is the radiation it absorbs. The advantage of this principle over the former is that it overcomes the errors introduced by the fact that a hot gas does not have exactly the same wave length as a cold gas. In this method, a selective source of infra-red is replaced by a non-selective emitter—a black hot wire—and the gas for which the test is to be made, carbon dioxide, for example, is placed in a closed cell. Any carbon dioxide in the test cell will remove its proportional amount of the radiation which would otherwise heat the closed carbon dioxide cell.

3. Negative filters—a double-beam differential method, one beam being desensitized to one gas by a high concentration filter of that gas in the beam. This principle is used in the instruments manufactured by Leeds and Northrop Company, Baird Associates, Inc., and that developed by Wright and Herscher, of the Dow Chemical Company, for use in plants of that concern.

Further details concerning such instruments and their applications have been published by Wright and Hersher.[4] A paper on infra-red gas analyzers presented at the Eighth Annual Meeting of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION by Fastie and Pford, of the Department of Physics, The Johns Hopkins University, is to be published shortly.[5] The optical diagram of a double-cell unit employing the negative filter principle is shown in Fig. 6.



Optical diagram of a double cell infra-red spectrometer

Other Photometric Methods

PHOTOMETRIC methods using ordinary light sources have been developed for continuous recording of concentrations of carbon disulfide and hydrogen sulfide.[6]

An apparatus schematically shown in Fig. 7 was used for carbon disulfide analysis. The vapor was burned in two furnaces to sulfur trioxide, passed over water to produce a sulfur trioxide fog which interrupted the passage of light to a photronic cell. One large division of the Leeds and Northrup Micromax recorder was equivalent to 1.5 parts per million of carbon disulfide with a lag of only a few seconds.

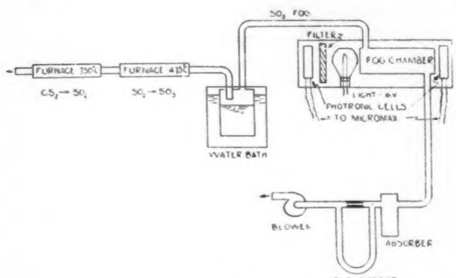


Fig. 7.
Photometric apparatus for carbon disulfide vapor recording

However, even though the maximum allowable concentration of carbon disulfide is 20 parts per million, the viscose-rayon industry, in connection with which this instrument was initially developed, has so reduced concentrations in many departments that there was some question as to whether the method was sufficiently sensitive for routine plant use.

A photometric method for hydrogen sulfide is shown schematically in Fig. 8. The air is drawn past a lead acetate impregnated paper and the degree of darkening due to the hydrogen sulfide is measured by photronic cells. The Micromax recorder is sensitive to 0.5 parts per million in the range of 0 to 10 parts per million. As the maximum allowable concentration for hydrogen sulfide is 20 parts per million, this sensitivity is adequate.

An automatic recording apparatus has been constructed by Hazard and Drinker for determination of the amount of dust in the air[7] and is illustrated in Fig. 9. The air being sampled is directed against a transparent film. A light source is divided into two beams, one passing through the film before and one after the dust has been deposited on it. The difference between the electrical current produced by the two photosensitive cells against which these light beams are directed is a measure of the amount of dust in the air sample and is recorded in the usual manner as a permanent record. This type of equipment has the advantage of recording all the variations and still giving data on the average exposure. It is necessary to calibrate the results obtained against other accepted methods such as the impinger in order to evaluate the results.

Electrical Conductivity

THE Thomas SO_2 autometer for the automatic determination of small concentrations of sulfur dioxide in air was first described in 1928. The most recent model of this ingenious device was described in June, 1946, by Thomas, Ivie, and Fitt.[8] The autometer, which may be mounted in a truck for field use

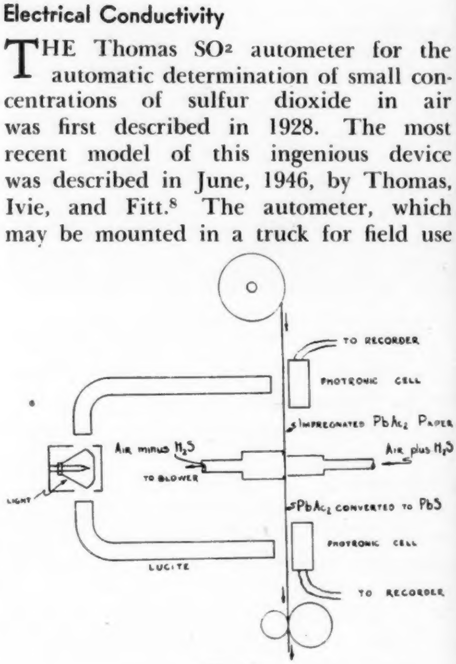


Fig. 8.
Photometric apparatus for hydrogen sulfide gas recording

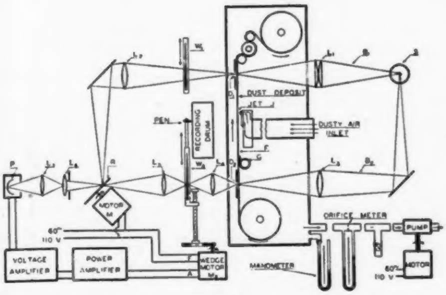


Fig. 9.
Automatic recording apparatus for determination of dust in air

but is not a readily portable instrument as the industrial hygienist usually considers portability, is illustrated diagramatically in Fig. 10. The apparatus may be used for determination of water-soluble gases such as sulfur dioxide, and hydrogen chloride.

The air sample enters the absorber at B and leaves at C. A pump impels the absorbing liquid to the top of the absorbing tube, down which it flows, countercurrent to the air sample, and on into the conductivity cell. When the cell is full, the recorder measures the electric current for one and a half minutes after which a solenoid pulls out the rubber plug at the bottom of the cell allowing the liquid to run out. The cycle is repeated after 27 minutes. The apparatus is sensitive to sulfur dioxide concentrations of 0.1 parts per million or more.

An earlier model of the Thomas SO_2 autometer was adapted by Reese, White, and Drinker[6] to the automatic recording of carbon disulfide and hydrogen sulfide. Air containing these materials, separately or in combination, were passed over heated platinum foil and the sulfur completely oxidized to sulfur dioxide. This Thomas instrument had a capacity to hold a week's supply of reagent and seemed to be satisfactory for recording of these materials in the air of viscose-rayon plants.

A portable unit employing this principle has just been developed at the laboratory of the Department of Toxicology and Industrial Hygiene of Merck and Company, at Rahway, New Jersey, and is commercially available through the Davis Emergency Equipment Company. The equipment is being constructed as a portable unit, weighing less than 35 pounds, to give a continuous reading and to be operated on 110 AC current, and also as a self-supporting panel with an electronic recorder for producing a permanent record. Any gas or vapor which is soluble and readily ionizes in water, or which will do so when decomposed by heat, can be readily analyzed by this instrument. This includes all chlorinated hydrocarbons, carbon disulfide, hydrogen sulfide, sulfur dioxide, oxides of nitrogen, and hydrogen chloride.

Depolarization Method

A UNIQUE method for determination of the concentration of oxygen in air has been developed recently by the Mine Safety Appliances Company. The sample is passed through a cell composed of a

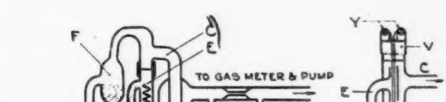


Fig. 10.
Thomas autometer for determination of ionizing gases such as sulfur dioxide and hydrogen chloride

metallic plate and a hollow carbon tube immersed in electrolyte. Oxygen in the sample, on diffusing through the porous carbon, combines with hydrogen adhering to the carbon electrode. This elimination of part of the nascent hydrogen increases the electromotive force of the cell by reducing its internal resistance. The current output of the cell accordingly increases with the partial pressure of oxygen in the sample. The device was designed primarily for analyzing gases in industrial processes, but it is adaptable to certain operations where there is danger of an oxygen-deficient atmosphere. The apparatus includes a continuous graphic recording of the oxygen concentration.

Future Needs and Applications

THE impelling need for more and more information on the atmosphere of the world we live in must necessarily lead to further development and refinement in the automatic indicating and recording instruments for air analysis.

A present problem on which research is going forward is apparatus for analysis of air 50 and 100 miles above the earth's surface. It is very probable that the application of a photometric or of an electric conductivity method will permit information to be obtained on the constituency of the rarified atmosphere at these distances from the earth. Since electric current changes are produced as a measure of the concentrations of the gases present, it would seem to be but a matter of technical detail to mount the equipment in a rocket, and provide a circuit to transfer this electrical energy to radio frequencies for transmittal to receiving stations on the earth. By this means it might be possible to continuously sample the atmosphere as the rocket sped on up, mile after mile, and permit a recording device, perhaps identical to one of those illustrated to inscribe a running record of data.

In the determination of radioactivity an impressive array of indicating instruments have been developed and are regularly used by bio-physicists and radio-biologists to keep informed on the amounts of radioactive energy to which the nuclear energy scientists may be exposed.

Certain of these instruments determine the amount of radioactivity to which the worker is exposed and integrate the exposure over the day or the week. Others determine the concentration of radiation in the areas where persons must conduct their operations.

The organic chemists are constantly synthesizing new materials, some of which possess properties of marked toxicity. At the same time, there is an increasing demand that occupational environment be not detrimental to health. If this objective is to be reached with the constantly increasing introduction of new toxic substances, it will be essential to have developed more and better instruments to permit a close check on exposures. Only by keeping continually informed as is possible through the more extensive application of automatic indicating and recording instruments can the industrial hygienist of today and tomorrow assure a healthful industrial environment.

References

1. KATZ, S. H., et al.: A carbon monoxide recorder and alarm. U. S. Bureau of Mines Technical Paper No. 355.

2. HANSON, V. F.: Ultra-violet photometer. Quantitative measurements of small traces of solvent vapors in air. *Ind. & Eng. Chem., Anal. Ed.*, 13:119, 1941.

3. KLOTZ, I. M., and DOLE, MALCOLM: An automatic-recording ultra-violet photometer for laboratory and field use. *Ind. & Eng. Chem., Anal. Ed.*, 18:741, 1946.

4. WRIGHT, N., and HERSHER, L. W.: Recording infra-red analyzers for butadiene and styrene plant streams. *J. Optical Soc. Amer.*, 36:195, 1946.

5. FASTIE, W. G., and PFORD, A. H.: Infra-red gas analyzers. *J. Optical Soc. Amer.*, October, 1947.

6. REECE, G. M., WHITE, BEN, and DRINKER, PHILIP: Determination and recording of carbon disulfide and hydrogen sulfide in the viscose-rayon industry. *J. Ind. Hyg. & Tox.*, 22:416, 1940.

7. HAZARD, W. G., and DRINKER, PHILIP: An atmospheric dust recorder. *J. Ind. Hyg. & Tox.*, 16:192, 1934.

8. THOMAS, M. D., IVIE, J. O., and FITT, T. C.: Automatic apparatus for determination of small concentrations of sulfur dioxide in air: New counter-current absorber for rapid recording of low and high concentrations. *Ind. & Eng. Chem., Anal. Ed.*, 18:383, 1946.

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